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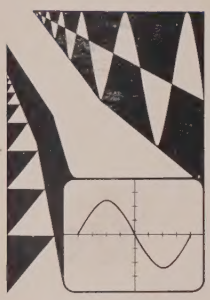

10 MHz Dual-beam oscilloscope

PM 3232

10 MHz Dual-beam oscilloscope with delay line

PM 3233

9499 440 11911 730309/1/03

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730618 PM 3232/03 PM 3233/01 Cd 786

TEST AND MEASURING INSTRUMENTS

Re: Mains transformer of PM 3232/03 and PM 3233/01

A. Modification

During production a different type of mains transformer has been applied, which is provided with a temperature-sensitive fuse (125 °C); this fuse is mounted between the transformer windings. Furthermore, a different type of voltage adapter has been mounted.

B. Consequences for the manual

Chapter 2.1.2. Mains connection and fuses

Use the following text:

Before switching-on, the instrument must be adjusted to the local mains voltage by means of the voltage adapter at the rear.

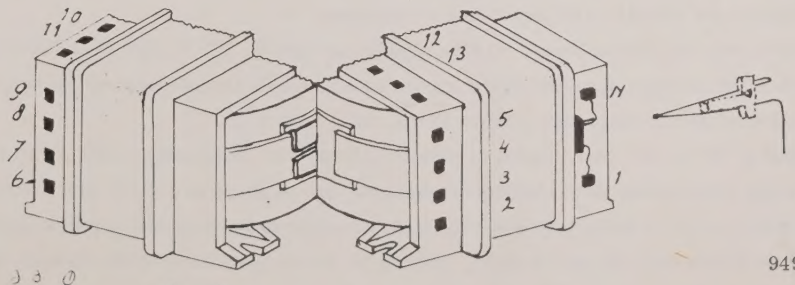
It is possible to adjust the instrument to 220 V, 127 V, 240 V and 110 V by means of a screwdriver. The selected voltage is visible through the opening at the rear.

The instrument can optionnaly (Spec. V) be adapted for 200 V, 127 V, 220 V and 100 V.

The temperature-sensitive fuse is mounted between the mains transformer windings. It can be replaced after having removed the rear cover (3 screws "X", Fig. 2-2).

Terminals "N" and "1" (see figure enclosed) must be unsoldered; in order to remove the fuse, bend the enclosure slightly to the outside so that the locking pin can be disengaged.

A new fuse is removed from its housing in the same way as described before. It is then pushed in the same enclosure as the old one until the locking pin snaps into the hole, the loop pointing to the "N" terminal. After having terminals "N" and "1" soldered, the instrument can be considered as ready for use.



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Betrifft: Netztransformator von PM 3232/03 und PM 3233/01

A. Änderung

Während der Produktion ist ein neuer Typ Netztransformator eingeführt worden. Er ist mit einer temperaturempfindlichen Schmelzsicherung (125 °C) ausgerüstet, die sich zwischen den Transformatorwicklungen befindet. Zugleich ist ein neuer Typ Spannungsumschalter eingebaut worden.

B. Änderungen in der Anleitung

Abschnitt 2.1.2. Netzspannungseinstellung und Sicherungen

Vor dem Einschalten ist das Gerät mit dem Spannungsumschalter an der Rückseite an die örtliche Netzspannung anzupassen.
Das Gerät kann mit einem Schraubenzieher auf 220 V, 127 V, 240 V und 110 V eingestellt werden.
Die gewählte Spannung ist durch eine Öffnung an der Rückseite des Geräts sichtbar.
Auf Wunsch (Spez. V) kann das Gerät auch für 200 V, 127 V, 220 V und 100 V geliefert werden.
Die temperaturempfindliche Sicherung befindet sich zwischen den Wicklungen des Netztransformators.
Sie kann nach Abnehmen der Rückwand ersetzt werden (drei Schrauben X, Abb. 2.2.).
Die Anschlüsse "N" und "1" (siehe Abb.) werden abgelötet. Zum Entfernen der Sicherung ist der Sperrnocken am Sicherungskörper freizulegen, indem man den Mantel etwas auswärtsbiegt.
Auf ähnliche Weise wird die neue Sicherung aus dem Gehäuse entfernt und, während die Schleife dem Anschluss "N" zugewandt ist, eingesetzt. Die Sicherung hineinschieben, bis der Nocken in die Sperröffnung einrastet. Nach Festlöten der Anschlüsse "N" und "1" ist das Gerät betriebsfertig.

-.-.-.-.-.-.-

Concerne: Transformateur secteur de PM 3232/03 et PM 3233/01

A. Modification

En cours de production un type différent de transformateur secteur a été appliqué, lequel est pourvu d'un fusible thermique (125 °C); ce fusible est monté entre les enroulements du transformateur secteur. De plus, l'adaptateur de tension est remplacé par un autre type.

B. Conséquences pour la notice d'emploi et d'entretien

Chapitre 2.1.2. Connexion secteur et fusibles

Utiliser le texte suivant:
Avant l'enclenchement, l'instrument doit être réglé sur la tension secteur locale à l'aide de l'adaptateur de tension situé à l'arrière de l'instrument.
Il est possible de régler l'instrument sur 220 V, 127 V, 240 V et 110 V à l'aide d'un tournevis. La tension sélectionnée est visible par l'ouverture à l'arrière.
l'appareil peut sur option (Spec. V) être adapté sur 200 V, 127 V, 220 V et 100 V.
Le fusible thermique est monté entre les enroulements du transformateur secteur. Il peut être remplacé après démontage du couvercle arrière (3 vis "X", Fig. 2-2).
Les bornes "N" et "1" (voir figure ci-jointe) doivent être dessoudées; afin d'enlever le fusible, courber l'enveloppe légèrement vers l'extérieur de sorte que la goupille d'arrêt soit libérée.
Un nouveau fusible s'extrait de son boîtier de la même façon que décrit précédemment. Il est ensuite poussé au même endroit que l'ancien, jusqu'à ce que la goupille d'arrêt s'adapte dans le trou, la cosse étant dirigée vers la borne "N". Souder ensuite les bornes "N" et "1", l'appareil est alors prêt à l'usage.

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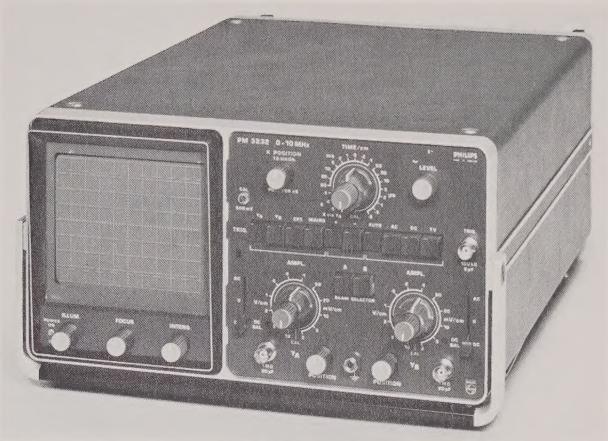

Operating manual

10 MHz Dual-beam oscilloscope **PM 3232**

10 MHz Dual-beam oscilloscope with delay line **PM 3233**

9499 440 11911

730309/1/03

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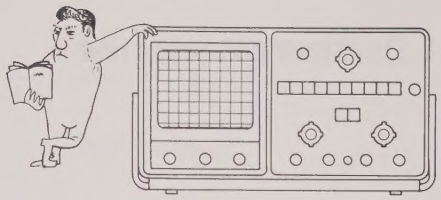
1. General information



1.1 . Introduction

The 10 MHz Dual-beam Oscilloscopes PM 3232 and PM 3233 have been designed for general laboratory, service and educational applications.
The vertical amplifiers are equipped with a drift-reduction and a fully protected field-effect transistor input.
All circuits are entirely transistorized and the transistors have been mounted on supports to enable quick servicing.
The instrument features a fully automatic facility which enables triggering on the line and frame sync pulses of a television signal.
The oscilloscope can be supplied from either a.c. mains or external d.c. sources.
PM 3232 and PM 3233 are identical in all respects, with the exception that the PM 3233 is equipped with a signal delay line unit.

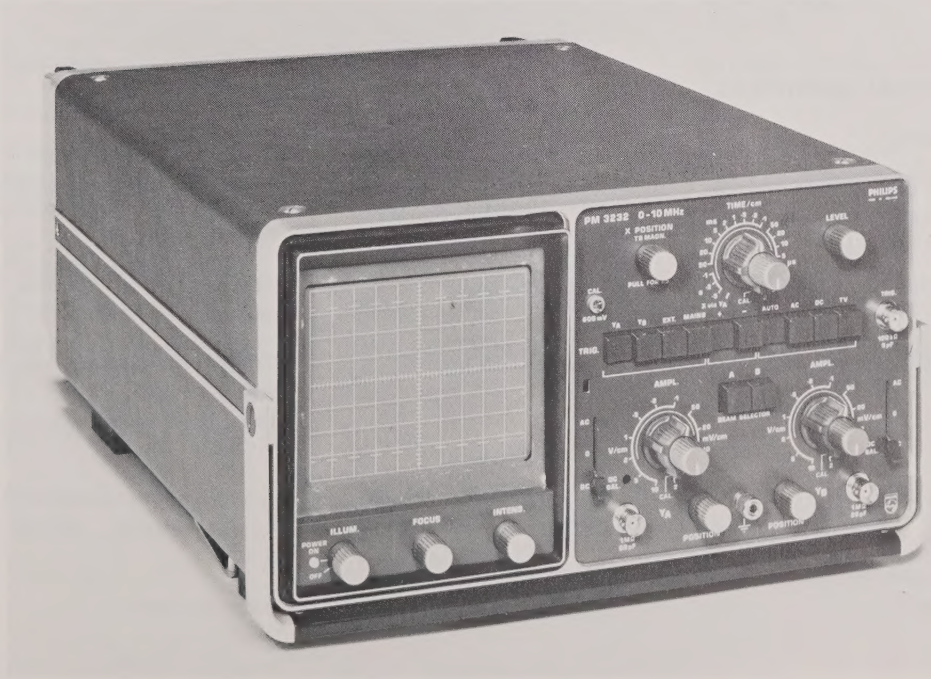


Fig. 1.1. Dual-beam oscilloscope

1.2. Characteristics

Properties expressed in numerical values with stated tolerance are guaranteed for nominal mains voltages. Numerical values without tolerances are typical values representing the characteristics of an average instrument.

DESIGNATION	*SPECIFICATION*	*ADDITIONAL INFORMATION*
1.2.1. C.R.T.		
Type	PHILIPS E14-100	Split-beam tube, mesh type, post-accelerator, metal-backed phosphor
Measuring area	80 mm x 100 mm	
Screen type	P31 (GH) phosphor	For P7 (GM) phosphor, order PM 3232G
Total acceleration voltage	10 kV	
Overlap of the two systems	100 %	Both in horizontal and vertical direction
Graticule	External, removable	Continuously variable illumination
Engravings	Centimetre divisions with sub-divisions of 2 mm along the central axes. Broken lines indicate 10 % and 90 % of measuring lattice.	
1.2.2. VERTICAL AMPLIFIERS		
1.2.2.1. Response		
Frequency range	d.c. ... 10 MHz 2 Hz ... 10 MHz	−3 dB bandwidth d.c. coupled −3 dB bandwidth a.c. coupled
Rise time	35 ns	
Overshoot	2 % at maximum	Test pulse of 1 ns rise time for 6 cm deflection at 1 MHz
1.2.2.2. Deflection coefficients	2 mV/cm ... 10 V/cm	Twelve calibrated positions in 1-2-5 sequence. Uncalibrated continuous control 1 : $\geqslant$ 2,5
1.2.2.3. Error limit	± 3 % ± 5 %	In range +5 °C ... +40 °C In range −10 °C ... +55 °C
1.2.2.4. Maximum permissible input voltage	± 400 V	d.c. + a.c. peak

DESIGNATION	*SPECIFICATION*	*ADDITIONAL INFORMATION*
1.2.2.5. Instability of the spot position		
Long-term drift = short-term drift	0,25 cm/hour	Typical value
1.2.2.6. Vertical positioning	16 cm	
1.2.2.7. Dynamic range	24 cm	Peak-to-peak amplitude for sine-wave signals; at 3 MHz negligible distortion
1.2.2.8. Input impedance	1 MOhm//20 pF	
1.2.2.9. Input RC time	0,1 s	Coupling switch to A.C.
1.2.2.10. Visible signal delay	$\geqslant$ 40 nsec	for PM 3233 only
1.2.3. X-Y MODE	X via Y_A	x5 magnifier inoperative
Horizontal frequency range	d.c. ... 1 MHz 2 Hz ... 1 MHz	
Phase shift	5^o	At 100 kHz
Additional error for Y_A channel	± 2 % ± 3 %	In range +5 °C ... +40 °C In range −10 °C ... +55 °C
1.2.4. TIME BASE		
1.2.4.1. Time coefficients	0,5 s/cm ... 0,2 μs/cm	Twenty calibrated positions in 1-2-5 sequence. Uncalibrated continuous control 1 : $\geqslant$ 2,5
1.2.4.2. Coefficient	± 5 %	In range −10 °C ... +55 °C
1.2.4.3. Expansion		
Magnification	5 x	Switched, calibrated
Additional error	± 2 % ± 3 %	In range +5 °C ... +40 °C In range −10 °C ... +55 °C
1.2.4.4. Time-base output signal		
Output voltage	300 mV	With 50 Ohm termination
Emf (open output voltage)	6 V_{p-p} (−2 V to +4 V)	The output terminal may be short-circuited without affecting the time coefficients
Internal resistance	1 kOhm	
1.2.4.5. Positioning range	The beginning and the end of the time-base line can be made visible	

DESIGNATION	*SPECIFICATION*	*ADDITIONAL INFORMATION*
1.2.5. **TRIGGERING**		
1.2.5.1. **Source**	Internal: channel Y_A, channel Y_B or mains freq. External	
1.2.5.2. **Trigger sensitivity**	Internal $\leqslant$ 1 cm at 10 MHz External $\leqslant$ 1 $V_{p\text{-}p}$ at 10 MHz	For sine-wave signals
1.2.5.3. **Input impedance**	100 kOhm//5 pF	
1.2.5.4. **Maximum permissible input voltage**	± 400 V	d.c. + a.c. peak
1.2.5.5. **Trigger mode**	Automatic or normal	
1.2.5.6. **Level range**	Corresponding to trace height 24 cm 24 V	In the automatic mode. In the normal mode. External.
1.2.5.7. **Triggering frequency range**	10 Hz ... 10 MHz d.c. ... 10 MHz 20 Hz ... 10 MHz	A.C. coupling D.C. coupling A.C. coupling in the automatic mode
1.2.5.8. **Triggering slope**	+ or –	
1.2.5.9. **Triggering with T.V. signals**		Fully automatic; level control switched off.
Mode	Frame	Coupled with positions 50 µs/cm ... 0,5 s/cm
	Line	Coupled with positions 0,2 µs/cm ... 20 µs/cm
Trigger sensitivity	1 cm sync pulse	
1.2.6. **INTENSITY MODULATION**		A.C. coupled
Blanking voltage	$\geqslant$ +20 V	
Input resistance	$\geqslant$ 47 kOhm	
Frequency range	20 Hz ... 1 kHz	
Maximum permissible input voltage	± 400 V	d.c. + a.c. peak
1.2.7. **CALIBRATION GENERATOR**		
Type	Square-wave generator	
Output voltage	600 $mV_{p\text{-}p}$	
Accuracy	± 1 %	In range +5 °C ... +40 °C
Frequency	approx. 2 kHz	

DESIGNATION	*SPECIFICATION*	*ADDITIONAL INFORMATION*
1.2.8. OPERATING CONDITIONS		
1.2.8.1. Supply	a.c. or d.c.	
Nominal voltage range	a.c. 90 V ... 140 V 180 V ... 265 V d.c. 22 V ... 30 V	
Nominal frequency range	46 Hz ... 400 Hz	
1.2.8.2. Ambient temperature		
Rated range of use	+ 5 °C ... +40 °C	
Limit range of operation	−10 °C... +55 °C	
Storage and transport conditions	−40 °C ... +70 °C	
1.2.8.3. Operating position	Any	
1.2.9. WARM-UP TIME	5 minutes	At constant ambient conditions (not including recovery time; see also section 2.4.5.)
1.2.10. POWER CONSUMPTION	40 VA at 220 V a.c. 20 W at 24 V d.c.	 0.85 A current drain
1.2.11. MAINS INTERFERENCE	The instrument meets the VDE Störgrad K requirement	
1.2.12. MECHANICAL DATA		
Design	Portable	
Dimensions	Depth 503 mm Width 326 mm Height 185 mm	Incl. front cover Incl. handle Incl. feet
Weight	Approx. 9,5 kg	
1.2.13. COOLING	Natural convection	
1.2.14. COMPONENT REPLACEMENTS	Normal production types, transistors plugged in	

1.3. Accessories

1.3.1. STANDARD ACCESSORIES

1 Front cover with storage space for two passive probes and two BNC-4 mm adapters
2 BNC-4 mm adapters PM 9051
1 Operating manual

1.3.2. OPTIONAL ACCESSORIES

Passive probe sets (10 : 1)	: PM 9326 and PM 9327
Passive probe sets (10 : 1)	: PM 9336 and PM 9336L
Passive probe set (1 : 1)	: PM 9335
2 kV passive probe set (100 : 1)	: PM 9358
Set of miniature probe clips	: PM 9333
Multi-purpose oscilloscope camera	: PM 9380
Adapter (oscilloscope to camera)	: PM 9379

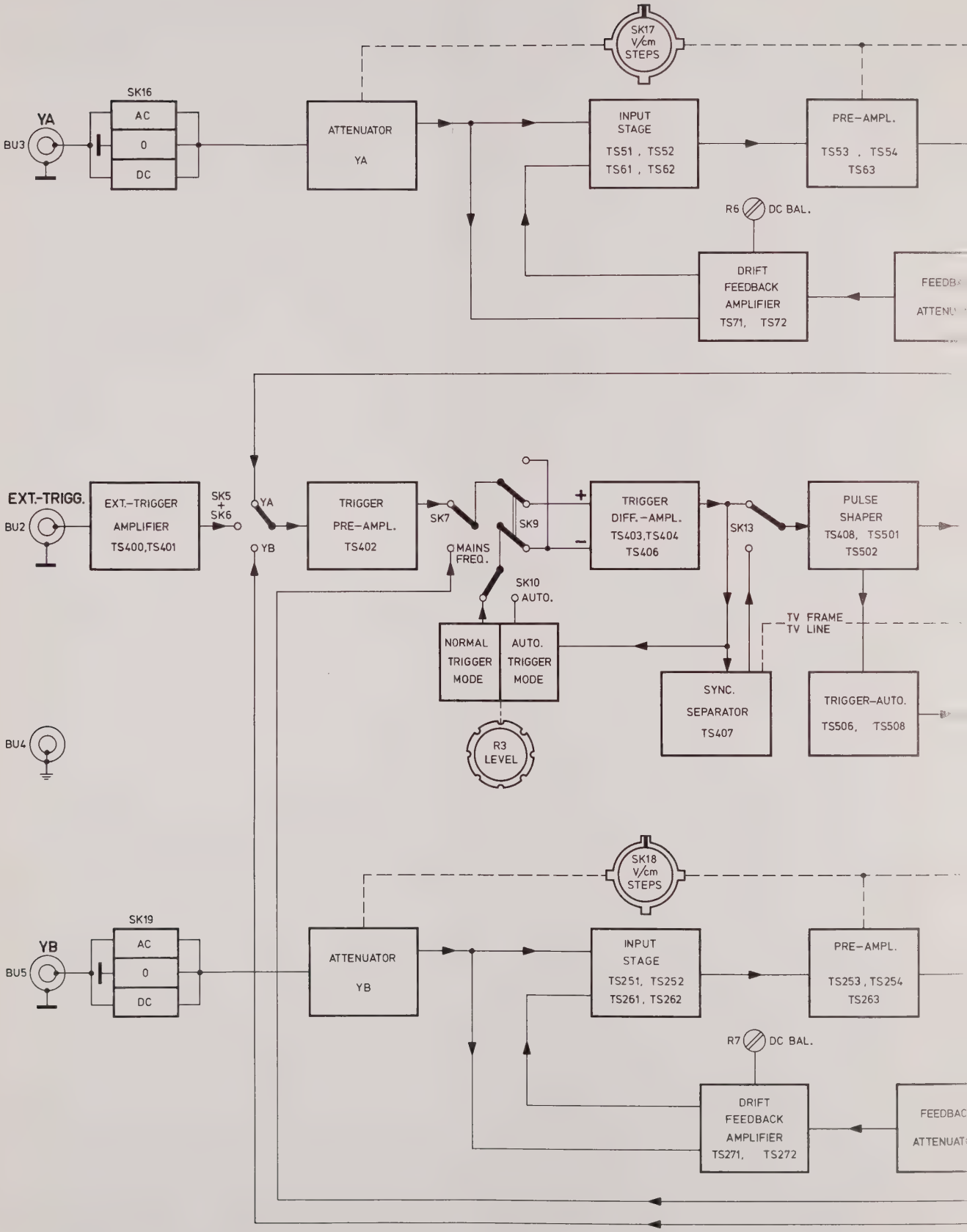
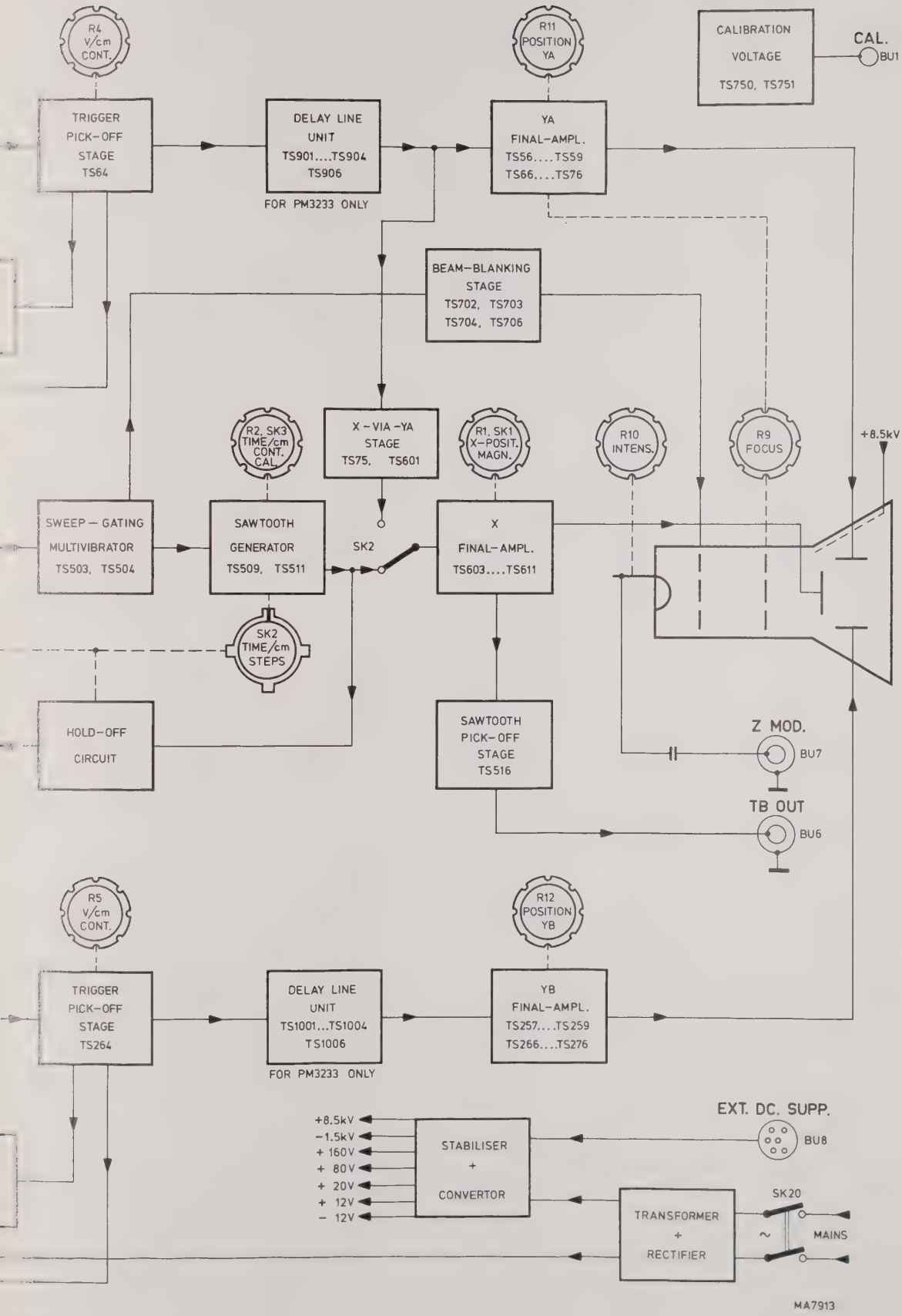


Fig. 1.2. Block diagram


R4 V/cm CONT.
TRIGGER PICK-OFF STAGE TS64
DELAY LINE UNIT TS901....TS904 TS906
FOR PM3233 ONLY
R11 POSITION YA
YA FINAL-AMPL. TS56....TS59 TS66....TS76
CALIBRATION VOLTAGE TS750, TS751
CAL.
BU1
BEAM-BLANKING STAGE TS702, TS703 TS704, TS706
R2, SK3 TIME/cm CONT. CAL.
X-VIA-YA STAGE TS75, TS601
R1, SK1 X-POSIT. MAGN.
R10 INTENS.
R9 FOCUS
+8.5kV
SWEEP-GATING MULTIVIBRATOR TS503, TS504
SAWTOOTH GENERATOR TS509, TS511
SK2
X FINAL-AMPL. TS603....TS611
SK2 TIME/cm STEPS
HOLD-OFF CIRCUIT
SAWTOOTH PICK-OFF STAGE TS516
Z MOD.
BU7
TB OUT
BU6
R5 V/cm CONT.
TRIGGER PICK-OFF STAGE TS264
DELAY LINE UNIT TS1001...TS1004 TS1006
FOR PM3233 ONLY
R12 POSITION YB
YB FINAL-AMPL. TS257....TS259 TS266....TS276
EXT. DC. SUPP.
BU8
+8.5kV
-1.5kV
+ 160V
+ 80V
+ 20V
+ 12V
- 12V
STABILISER + CONVERTOR
TRANSFORMER + RECTIFIER
SK20
~
MAINS
MA7913

1.4. Description of the block diagram

1.4.1. Y AXIS

The oscilloscopes PM 3232 and PM 3233 have two identical, d.c. coupled vertical amplifiers allowing simultaneous display of two signals. Each amplifier comprises an input step-attenuator, a source follower with protection circuitry, a pre-amplifier and a drift reduction circuit, a trigger pick-off stage and a final amplifier. In the PM 3233, the trigger pick-off stage and the final amplifier (for both channels, Y_A and Y_B) have been coupled by means of a delay line.
The protection circuitry prevents damage to the input field-effect transistors by too high an input voltage. The drift-reduction circuit reduces the drift inherent in the high sensitivity of the amplifier.

The trigger pick-off stage supplies a triggering signal to the trigger pre-amplifier in case of internal triggering, and also couples the signal to the Y final amplifier. In the Y_A channel the signal can also be coupled to the X final amplifier if the instrument is used as an XY oscilloscope. From the Y final amplifier, the signal is fed to the Y deflection plates of the c.r.t.

The delay line has been applied to enable the display of the leading edge of fast phenomena on the screen.

1.4.2. TRIGGERING

A triggering signal can be obtained from either vertical amplifier, from an external source or internally from the mains. The latter signal is not available when the instrument is supplied with an external d.c. voltage. The triggering signal is fed to a trigger pulse shaper which supplies well-defined trigger pulses to start the time-base generator. The trigger unit also comprises a sync separator for television signals so that triggering by means of these signals is also possible.

1.4.3. TIME BASE

The time-base generator is of the constant-current integrator type and supplies two output voltages.
A sawtooth voltage which is fed to the X final amplifier and an output socket at the rear of the oscilloscope and a gate pulse which controls the unblanking of the c.r.t. during the sweep.

1.4.4. X AXIS

The X final amplifier receives its input signal from either the time-base generator or from an external source via the Y_A channel. From the X amplifier the signal is fed to the horizontal deflection plates of the c.r.t. of the oscilloscope.

1.4.5. CATHODE-RAY TUBE CIRCUIT

The cathode-ray tube is of the split-beam type with one control for the brilliance of the trace and one for focusing. The cathode of the c.r.t. is a.c. coupled to a socket for external Z modulation.
The high voltages for the c.r.t. are generated by a converter which also delivers the other supply voltages.

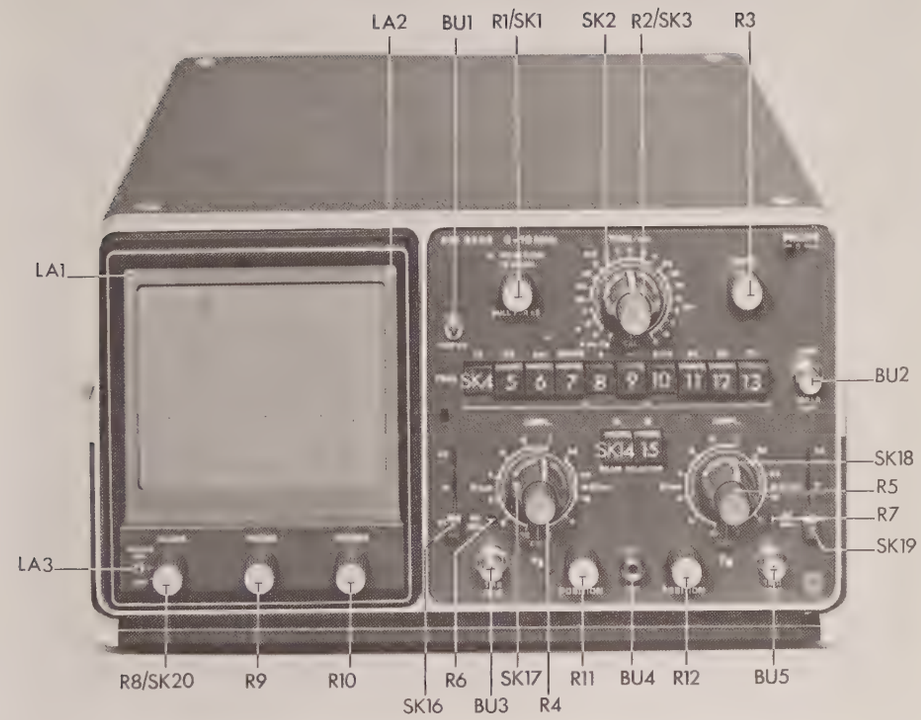
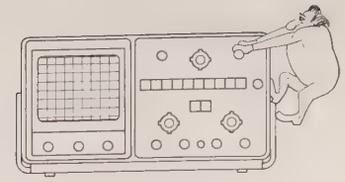


Fig. 2.1. Front view showing controls and sockets

2. Directions for use



2.1. Installation

2.1.1. REMOVING AND FITTING THE FRONT COVER

Removing: – Turn the knob in the centre of the cover a quarter of a turn anti-clockwise.
– Take the cover off.

Fitting: – Align the key of the locking knob with the slot in the text plate of the instrument.
– Fit the cover over the front of the oscilloscope.
– Press the knob and turn it a quarter of a turn clockwise.

WARNING

This instrument generates high voltages and should not be operated with the covers removed. The mains plug or external voltage source should be removed before attempting any maintenance work, and any relevant high voltage points discharged.

2.1.2. MAINS ADJUSTMENT AND FUSES

Before switching on, the instrument should be adjusted to the local mains voltage by means of the voltage adapter at the rear of the instrument.

Provision is made for selecting 100 V (Spec V), 110 V, 127 V, 200 V, 220 V and 240 V nominal mains voltage. The selected voltage is displayed through a hole in the rear of the instrument.
The mains voltage adapter can be set after removal of the rear cover (three screws Fig. 2.2.): pull out the adapter and turn it until the value required is in the uppermost position. Then push the adapter inwards again.

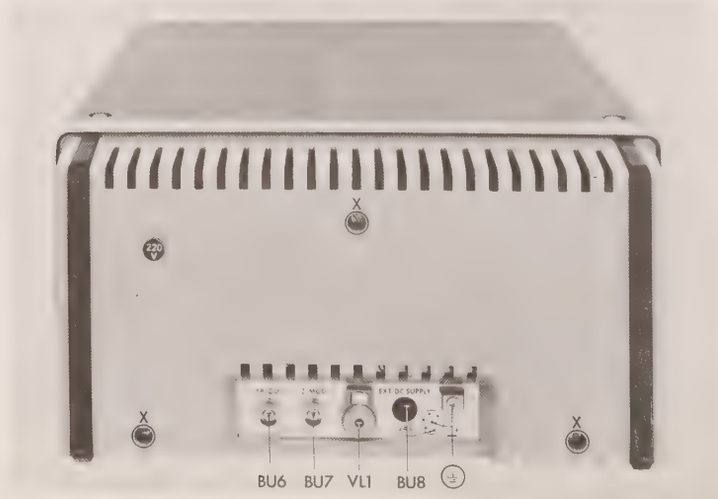


Fig. 2.2. Rear view showing sockets

The fulse holder on the rear panel normally carries a 250 mA delayed action mains fuse but if the instrument is to be connected to a mains voltage of less than 200 V, a 500 mA fuse must be fitted.
Check that the fuse is of the specified type and current rating before connecting the oscilloscope to the mains. The use of repaired fuses and the short-circuiting of fuse holders is prohibited.

2.1.3. SUPPLY FROM AN EXTERNAL D.C. SOURCE

The instrument may be supplied from an external d.c. source of 22 V to 30 V, 0,85 A. This voltage is to be applied to EXT. D.C. SUPPLY socket BU8. THE POSITIVE TERMINAL OF THE VOLTAGE SOURCE MUST BE CONNECTED TO EARTH, AS INDICATED IN THE DIAGRAM ON THE REAR TEXT PLATE, SINCE THE POSITIVE SIDE OF THE POWER SUPPLY IS CONNECTED TO CHASSIS.
The instrument is protected against reverse connection. In the case of external d.c. supply, the instrument is protected by fuse VL802 (fig. 2.3.) which is located on the power supply board and accessible after removing the rear cover. VL802 is a delayed action, 1,25 A fuse.

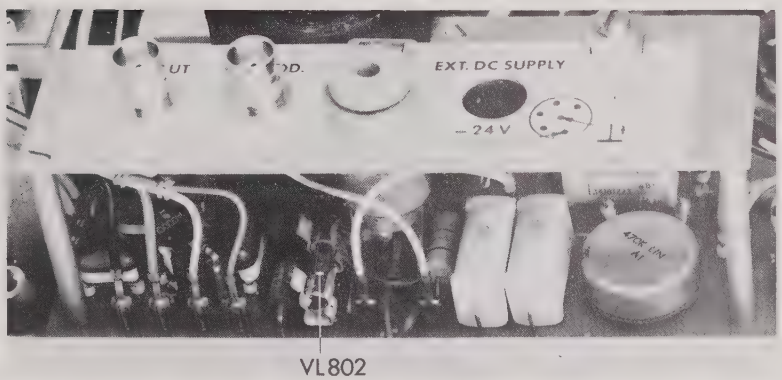


Fig. 2.3. Rear view showing fuse VL802

2.1.4. EARTHING

In the interests of safety, the oscilloscope must be connected to earth via the rear earthing terminal (identified by the symbol ⏚) or via the mains lead, provided that the supply socket is equipped with an earth connection. Care must be taken that the earth line to the oscilloscope is not interrupted due to the use of an extension lead or device which is not fitted with an earth conductor.

2.1.5. SWITCHING ON

The instrument is switched on in case of mains supply, by means of the mains switch incorporated in the ILLUM. control. The mains cable is located in a compartment at the bottom of the instrument.

In case of external d.c. supply, the mains switch is inoperative and the instrument is on as soon as the external source is connected. In both cases, the ON position is indicated by the white pilot lamp.

The instrument may be used in any position, but care should be taken that a free air circulation is not impeded. For temperature conditions refer to section 1.2.8.2.

2.2. Operating instructions

Before switching on, ensure that the oscilloscope has been correctly installed in accordance with chapter 2.1. Installation, and that the precautions outlined have been observed.

2.2.1. CONTROLS AND SOCKETS (Fig. 2.1.)

X POSITION (R1) MAGN. (SK1)	Continuously variable control giving horizontal positioning of the display. Incorporates a switch for calibrated 5x magnification of the time base.
TIME/cm (SK2)	Time-coefficient control of the time-base; 21-way switch with a position for external X deflection (X via Y_A).
CAL. - TIME/cm (R2/SK3)	Continuously variable control of the time coefficients. In the CAL. position the time-coefficient is calibrated.
LEVEL (R3)	Continuously variable control to select the level at which the time-base generator starts.
CAL. (BU1)	Outlet for square-wave voltage of 600 mV_{p-p} for calibration purposes.
TRIGGERING (SK4 ... 13)	Controls for trigger source, slope and mode; 10-way push-button switch.
Y_A (SK4)	Internal triggering signal derived from channel Y_A.
Y_B (SK5)	Internal triggering signal derived from channel Y_B.
EXT. (SK6)	Triggering signal derived from a voltage applied to the TRIGG. input socket.
MAINS (SK7)	Triggering signal derived from an internal voltage with the mains frequency. This trigger source is inoperative when the instrument is supplied with an external d.c. voltage.
+ (SK8)	Provides for triggering on the positive slope of the signal.
– (SK9)	Provides for triggering on the negative slope of the signal.
AUTO (SK10)	Provides for a free-running time-base in the absence of triggering signals and automatic signal-derived limitation of the LEVEL control range.
AC (SK11)	Triggering with coupling capacitor in triggering-signal path.
DC (SK12)	Direct coupling for triggering on a slowly varying voltage, or for full-bandwidth working.
TV (SK13)	Enables triggering on either line or frame pulses of TV signals, as dictated by the position of TIME/cm switch SK2. Triggering on frame pulses in positions 50 μs/cm to 0,5 s/cm and on line pulses in positions 0,2 μs/cm to 20 μs/cm.
TRIGG. (BU2)	Input BNC socket for external triggering signals.
BEAM SELECTOR A (SK14)	If this push-button is depressed, vertical deflection is achieved by the signal connected to the channel Y_A input.

BEAM SELECTOR B (SK15)	If this push-button is depressed, vertical deflection is achieved by the signal connected to the channel Y_B input. If both switch A (SK14) and switch B (SK15) are depressed, vertical deflection is achieved by both the signal connected to the channel Y_A input and the signal connected to the channel Y_B input.
AC-0-DC (SK16 & 19)	Signal coupling, three position switch. AC : via a coupling capacitor 0 : interruption of connection between input socket and input circuit, the latter being earthed. DC : Direct coupling.
AMPL. (SK17 & 18)	Control of the vertical deflection coefficients, 12-way switch.
CAL. - AMPL. (R4 & 5)	Continuously variable control of the vertical deflection coefficients. In the CAL. position, the deflection coefficient is calibrated.
DC BAL. (R6 & 7)	Continuously variable control of the direct-voltage balance of the vertical amplifier.
ILLUM. (SK20 & R8)	Continuously variable control of the graticule illumination. Incorporates mains switch.
FOCUS (R9)	Continuously variable control of the electron-beam focusing.
INTENS. (R10)	Continuously variable control of the trace brilliance.
1 MOhm – 20 pF (BU3 & 5)	Input BNC socket for the vertical deflection signals.
POSITION (R11 & 12)	Continuously variable control giving vertical positioning of the display.
⏚ (BU4)	Earth socket.

At the rear of the instrument (Fig. 2.2.):

TB OUT (BU6)	Sawtooth output BNC socket.
Z MOD. (BU7)	Input BNC socket for intensity-modulation voltages.
EXT. DC SUPPLY (BU8)	Input socket for d.c. supply.

2.2.2. PRELIMINARY SETTINGS

We recommend to allow a warm-up time of five minutes before you start your measurements. This warm-up time does not include a recovery time when the instrument comes in from the cold (see also section 2.4.5.).

- In case of mains operation:
  Check that the mains voltage adapter indicates the local mains voltage. If necessary, set the adapter to the relevant voltage in accordance with section 2.1.2. and check that the right fuse has been inserted.
  Switch on the instrument.
- In case of external d.c. supply:
  Check that the external source is properly connected, with the positive terminal to earth.
- Set FOCUS control R9 and INTENS. control R10 to their mid-positions.
- Depress BEAM SELECTOR buttons A SK14 and SK15. Bear in mind that their will be no display if no BEAM SELECTOR button is depressed.
- Select trigger source, slope and mode. If no TRIGG. button has been depressed, the oscilloscope triggers on the Y_A signal, on the positive slope and in an AUTO mode without level range limitation.
- Display the two traces by means of Y POSITION controls R11 and R12.

The oscilloscope is then ready for use. For correction of the d.c. balance, refer to section 2.2.2.1.

2.2.2.1. D.C. Balance (R6, R7)

- Depress Y_A (Y_B) switch SK4 (SK5), + switch SK8 and BEAM SELECTOR switch A SK14 (B SK15).
- Set AC-0-DC switch SK16 (SK19) to 0.
- Set AMPL potentiometer R4 (R5) to CAL.
- Check that the trace does not shift if AMPL switch SK17 (SK18) is switched from .1 V/cm to 2 mV/cm. If necessary, readjust DC BAL R6 (R7). During the adjustment, the trace must be kept in the centre of the screen by means of POSITION potentiometer R11 (R12).
- Check that the position of the trace is the same in positions 2, 5, 10, 20, 50 and 100 mV/cm of AMPL switch SK17 (SK18); maximum allowable difference 4 mm.

2.2.3. INPUTS Y_A AND Y_B AND THEIR POSSIBILITIES

The PM 3232 and PM 3233 have been provided with two identical vertical channels each which can be used for either YT measurements in combination with the time-base generator, or XY measurements up to frequencies of 1 MHz.

2.2.3.1. YT Measurements

To display one signal, either of the two vertical channels can be selected by operating either BEAM SELECTOR A SK14 or BEAM SELECTOR B SK15. When both push-buttons A SK14 en B SK15 are depressed, two signals can be displayed simultaneously. The Y deflection coefficient can be individually set for each channel.

2.2.3.2. XY Measurements

If TIME/cm switch SK2 is set to position X via Y_A, the time-base generator is switched off. The signal of the Y_A channel is displayed horizontally. The Y_A controls, except the POSITION potentiometer R11, then control the X deflection. Positioning of the trace in horizontal sense is still possible with X POSITION control R1. The x5 MAGNIFIER switch SK1, however, is inoperative.
In this mode, XY measurements can be up to a frequency of 100 kHz.

2.2.3.3. Influence of the AC-0-DC switch

Signals to be studied can be fed to Y_A input socket BU3 and/or to Y_B input socket BU5. Depending on the composition of the signal, the AC-0-DC switch should be set to position AC or DC. In position DC, the input is coupled direct to the Y amplifier. Because the Y amplifier is d.c. coupled, the entire bandwidth of the instrument is available. This means that the complete input voltages are fed to the deflection plates, which implies that the d.c. components result in trace shifts on the screen.
This may cause difficulties when a.c. signals superimposed on high direct voltages have to be displayed.

In order to make the a.c. signal visible in those cases, a greater attenuation will be necessary with the result that the a.c. signal will also be strongly attenuated.

In this case the AC-0-DC switch can be set to position AC. Then a blocking capacitor is connected between the input socket and the Y amplifier. As a result of this, d.c. voltages are blocked, but also the lower frequencies are suppressed or attenuated. When square-wave signals of low frequency are displayed, this will result in some pulse droop.
In the 0 position of the AC-0-DC switch it is possible to quickly determine the zero volt d.c. level.
In this position the connection between the amplifier input and the input socket is interrupted, the amplifier input being earthed. At the same time, the blocking capacitor is discharged to prevent damage of the circuit under test by a possible high charge.

2.2.4. TRIGGERING

2.2.4.1. General

In order to obtain a stationary trace, the horizontal deflection must always be started at a fixed point of the signal. The time-base generator is, therefore, started by narrow trigger pulses formed in the trigger unit, controlled by a signal originating from the vertical input signal or an external source.

2.2.4.2. Trigger coupling

AC If the signal voltage contains a d.c. component triggering can cease when the level potentiometer cannot supply the correct d.c. level for the Schmitt trigger. In this case it is useful to apply a.c. coupling. A.C. Coupling is obtained by inserting a capacitor in the trigger path. This means that the signal can still be d.c. coupled to the Y channels.

DC D.C. Coupling is useful when the mean value of the signal varies. This sort of signal often occurs in digital systems. With a.c. coupling the trigger point would not be fixed which would give rise to jitter or even loss of triggering.

2.2.4.3. Trigger level

In case of a complicated signal in which a number of non-identical voltage shapes occur periodically, the time axis should always be started with the same voltage shape so as to obtain a stationary trace. This is possible when one of the details has a deviating amplitude. By means of the LEVEL knob, the trigger level can be set in such a way that only this larger voltage variation passes this level. The LEVEL control is also very useful when two signals must be accurately, compared e.g. in phase measurements. By means of the LEVEL control the starting point of the traces can then be shifted exactly on to the control graticule line.

2.2.4.4. Automatic triggering

Automatic triggering, when the AUT switch is depressed, is most often used on account of its simple operation. In this mode it is possible to display a large variety of waveforms having different amplitude and shape, without it being necessary to operate any of the trigger controls.
If no triggering signal is present, a time-base line remains visible on the screen. This is useful for zero reference purposes. In this trigger mode the level can be adjusted over the peak-to-peak value of the a.c. component of the signal. If none of the switches AUT, AC, DC or TV is depressed, the oscilloscope works in the automatic mode, but with the entire level range available. This has the advantage that there is always a trace visible, even when no TRIGG. push-buttons are depressed.

2.2.4.5. External triggering

External triggering is applied for signals having a strongly varying amplitude, if a signal having a fixed amplitude and equal frequency is available. Even more important is external triggering in case of complex signals and pulse patterns. Then external triggering can be used to avoid double traces.
This obviates the necessity of readjusting the level setting at every variation of the input signal.

2.2.4.6. Triggering with the mains frequency

In this case the triggering signal is a sine-wave with the mains frequency. This trigger source is useful if the frequency of the signal under observation is coupled with the mains frequency.
It is, e.g., possible to recognize the hum component of a signal by triggering on that component.

2.2.4.7. Triggering with television signals

It is possible to trigger on the line or frame sync pulses of television signals. In positions .5 s to 50 μs of the TIME/cm switch triggering takes place on the frame sync pulses and in positions 20 μs to .2 μs on the line sync pulses of the signal.
The position of the trigger slope switches must correspond to the polarity of the video information of the signal.

2.2.5. TIME-BASE MAGNIFIER

The magnifier is operated with a push-pull switch.
When this switch is in the x5 position, the time-base sweep speed is increased 5 times. In this position the sweep time is determined by dividing the indicated TIME/cm value by 5.

2.2.6. Z MODULATION

In order to bring extra information in the c.r.t. display without changing the waveform, the brightness of the trace can be lowered by an externally applied voltage. The external signal must, therefore, be fed to the Z MOD socket at the rear of the oscilloscope.
The voltage required for visible brightness modulation depends on the position of the INTENS control. With an average brightness of the trace, a +20 $V_{p\text{-}p}$ voltage is amply sufficient for obtaining a good visible Z modulation.

2.3. Applications

In the following we describe the procedure and technique for basic measurements with the PM 3232 and PM 3233 oscilloscopes.

2.3.1. VOLTAGE MEASUREMENTS

Display the waveform as large as possible in order to obtain maximum accuracy. For all voltage measurements the AMPL. potentiometers must be in the CAL. position, otherwise the deflection coefficients are not calibrated.

When using a 10 : 1 attenuator probe, observe that the displayed amplitude must be multiplied by a factor 10. Ensure that the probe is adjusted for good step response, and, in the interest of accuracy, that the gain is checked with the aid of the CAL. voltage.

2.3.1.1. Peak-to-peak voltage measurements

To measure the peak-to-peak value of the a.c. component of a waveform, connect the signal to one of the Y input sockets and adjust the Y controls to display as large a trace as possible. Then proceed as follows:

1. Set the TIME/cm switch to display a few cycles of the waveform as illustrated in Fig. 2.4.
2. Adjust the Y POSITION control so that the lower peaks of the waveform coincide with the nearest horizontal graticule line.
3. Adjust the X POSITION control so that one of the upper peaks of the signal coincides with the central vertical graticule line.
4. Measure the vertical distance between the peaks of the signal.
5. Multiply the measured distance by the voltage setting of the AMPL. switch, and by the attenuation factor of the probe if any.

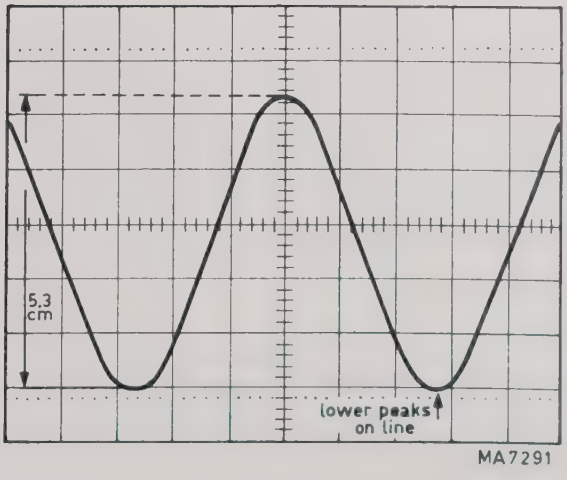


Fig. 2.4. Peak-to-peak voltage measurement

Example: Assume that the AMPL. switch is set to 2 mV/cm and a 10 : 1 attenuator is used. The measured vertical distance is 5,3 cm.

Using the formula: $V_{p\text{-}p}$ = (vertical distance) . (AMPL. setting) . (probe attenuation)
$= 5{,}3 \cdot 2 \cdot 10^{-3} \cdot 10 = 106$ mV

If the waveform is purely sinusoidal, the r.m.s. voltage is:

$$V_{r.m.s.} = \frac{V_{p\text{-}p}}{2\sqrt{2}} = \frac{106.10^{-3}}{2\sqrt{2}} = 38{,}2 \text{ mV}$$

2.3.1.2. Instantaneous-voltage measurements

To measure the instantaneous voltage of a waveform, connect the signal to one of the Y input sockets and adjust the Y controls to display as large a trace as possible.
Then proceed as follows:

1. Set the Y input switch to 0 and adjust the Y POSITION control so that the zero reference line coincides with the nearest horizontal graticule line.
   THE Y POSITION CONTROL MUST NOT BE MOVED AFTER THIS REFERENCE LINE HAS BEEN ESTABLISHED.
2. Set the Y input switch to DC.
3. If desired, rotate the X POSITION control so that the point to be measured lies on the vertical centre line.
4. Measure the vertical distance between this point and the zereo-reference line. If the point lies above the reference line, the voltage is positive; if the point lies below the line, the voltage is negative.
5. Multiply the measured distance by the voltage setting of the Y AMPL. switch and the attenuation factor of the probe if any.

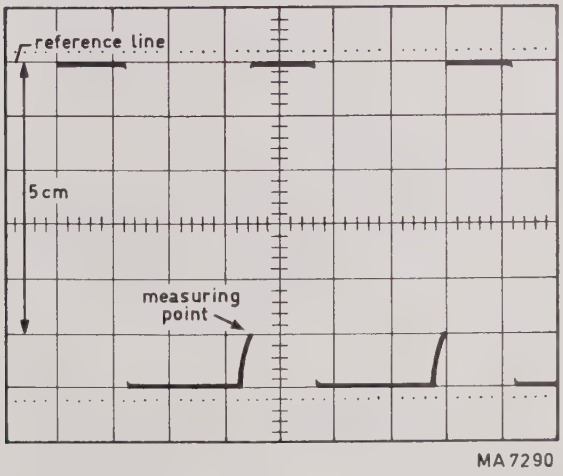


Fig. 2.5. Instantaneous-voltage measurement

Example: Assume that the Y AMPL. switch is set to .1 V/cm and that a 10 : 1 attenuator probe is used. The measured vertical distance is 5 cm (Fig. 2.5.).

Using the formula V_{inst} = (vertical distance) . (Y AMPL setting) . (probe attenuation)
$= 5.10^{-1} \cdot 10 = 5$ V, of negative polarity.

TO MEASURE A VOLTAGE LEVEL WITH RESPECT TO ANOTHER VOLTAGE RATHER THAN TO EARTH, APPLY THE REFERENCE VOLTAGE TO THE INPUT SOCKET.
ADJUST THE Y POSITION CONTROL, SO THAT THE TRACE COINCIDES WITH A HORIZONTAL GRATICULE LINE WHICH CAN NOW BE USED AS THE REFERENCE LINE.
THIS REPLACES THE ZERO-REFERENCE PROCEDURE DESCRIBED IN STEP 1.

2.3.2. TIME AND FREQUENCY MEASUREMENTS

For all time and frequency measurements, the TIME/cm potentiometer must be in the CAL. position, otherwise the sweep speeds are not calibrated.

2.3.2.1. Time measurements

To measure the time interval between two points of a waveform, connect the signal to one of the Y input sockets and adjust the Y controls to display as large a trace as possible. Then proceed as follows:

1. Set the TIME/cm switch so that the horizontal distance between the time-measuring points is as large as possible.
2. Rotate the X POSITION control so that one of the measuring points coincides with the nearest vertical graticule line.
3. Rotate the Y POSITION control to bring the other point to the horizontal centre line.
4. Measure the horizontal distance between the two time-measuring points.
5. Multiply the measured distance by the TIME/cm setting (if magnification is used, divide this product by 5).

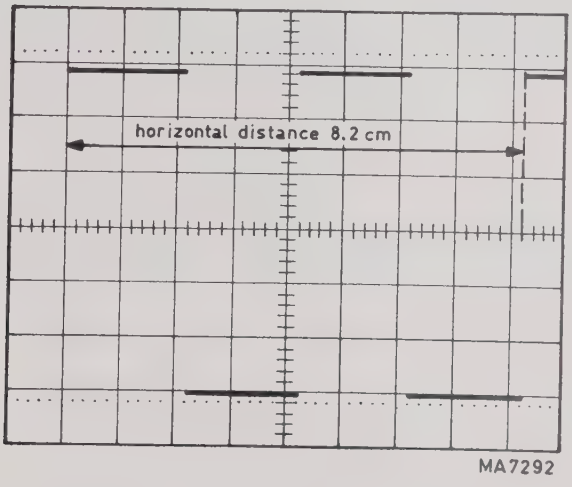


Fig. 2.6. Measuring a time interval

Example: Assume that the TIME/cm setting is .5 μs/cm and the magnifier is on. The measured distance is 8,2 cm (Fig. 2.6.).

Using the formula

$$\text{Time interval} = \frac{\text{horizontal distance . TIME/cm setting}}{\text{magnification}}$$

$$= \frac{8{,}2 \,.\, 5 \,.\, 10^{-7}}{5} = 0{,}82\ \mu s$$

After measuring the time duration of one cycle in the way described above, the frequency can easily be calculated:

$$\text{Frequency} = \frac{1}{\text{time duration of one cycle}}$$

2.3.2.2. Rise-time measurements

Rise time t_r is defined as the time required by the leading edge of a signal to rise from 10 % to 90 % of the amplitude.
When the oscilloscope rise time is comparable with that of the signal under test, the actual rise time should be calculated as follows:

$$\text{actual } t_r = \sqrt{(\text{measured } t_r)^2 - (\text{oscilloscope } t_r)^2}$$

This calculation is not necessary when the signal rise-time is longer than 150 ns (the error is then 5 % and decreases rapidly when the rise-time becomes longer).

To measure the rise time of a signal, connect the signal to one of the Y input sockets and adjust the Y controls to display as large a trace as possible. Then proceed as follows:

1. Set the TIME/cm switch to display the total step on the screen.
2. Adjust the Y amplitude so that the vertical deflection is exactly 8 cm. The 10 % and 90 % points now coincide with the dotted lines of the graticule.
3. Adjust the X POSITION control so that the 10 % point coincides with the nearest vertical graticule line; this line now is the reference line, and no further adjustment of the X POSITION control should be made.
4. Measure the horizontal distance between the time-reference line (coincident with the 10 % point) and the point of intersection of the signal and the horizontal 90 % line.
5. The rise-time is given by the product of the horizontal distance in cm and the TIME/cm setting.
   If magnification is used, this product must be divided by 5.

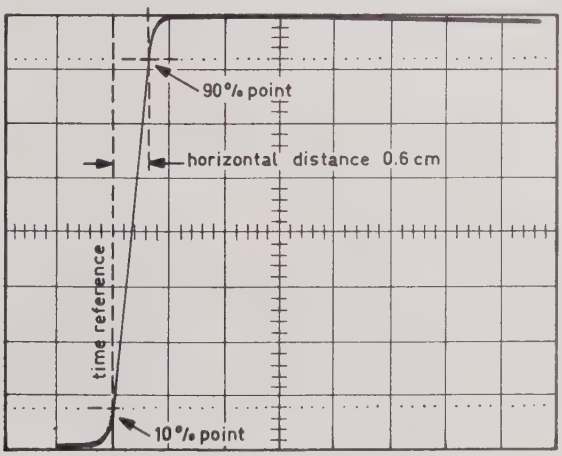


Fig. 2.7. Measuring the rise time of a signal

Example: Assume that the TIME/cm setting is .2 μs and magnification is not used. The oscilloscope rise time is 35 ns.
The measured distance is 0,6 cm (Fig. 2.7.).

Using the formula

$$\text{Measured rise-time} = \frac{\text{TIME/cm setting . horizontal distance}}{\text{magnification}}$$

$$= \frac{2 \cdot 10^{-7} \cdot 6 \cdot 10^{-1}}{1} = 120 \text{ ns}$$

Substituting in the formula:

$$\text{actual rise time} = \sqrt{(\text{measured rise-time})^2 - (\text{oscilloscope rise-time})^2}$$

$$= \sqrt{14400 - 1225} = \sqrt{13175} \approx 115 \text{ ns}$$

When measuring fast rise times, it is useful to start the time-base generator by means of a pre-pulse applied to the external trigger input. The time relation between the pre-pulse and the signal under test should be such, that the complete leading edge of the signal under test is displayed.

2.3.3. PHASE MEASUREMENTS

To measure the phase difference between two sine-wave signals, use the following method.
Connect one signal to the Y_A input socket and the other to the Y_B input socket, using probes or coaxial cables of the same type and length, thus, WITH EQUAL TIME DELAYS. Display the traces using the AUTO mode of the time-base. With a stable display of maximum amplitude, adjust the Y POSITION controls for symmetry about the horizontal centre line, and adjust the LEVEL control in such a way that the starting point of the first signal lies on the horizontal centre line.
When you have set up the display, proceed as follows:

1. Set the TIME/cm switch and potentiometer to such positions that half a cycle of the first signal occupies exactly 9 cm horizontally; i.e. each cm represents $180^o/9 = 20^o$.
2. Measure the horizontal distance between the two corresponding points on the waveforms and multiply this by 20^o to obtain the phase difference.

For small phase differences (less than 45^o) use the x5 magnifier. The phase scale is then 4^o/cm.
Therefore, the measured distance in cm must be multiplied by 4^o to obtain the desired phase difference.

2.3.4. XY MEASUREMENTS

As examples of the use of the XY-measurements we shall describe methods to display a hysteresis loop and a diode characteristic.

2.3.4.1. Displaying a hysteresis loop (Figs. 2.8. & 2.9.)

In displaying hysteresis loops of magnetic material, the magnetic induction B is plotted as a function of field strength H. If the iron core of a coil contains no air gaps, the field strength is proportional to the current through the number of windings. The primary current is thus a measure of the field strength H. A resistor R_p is connected in series with the primary. The voltage across this resistor is applied to the Y_A input (TIME/cm switch in position X via Y_A).

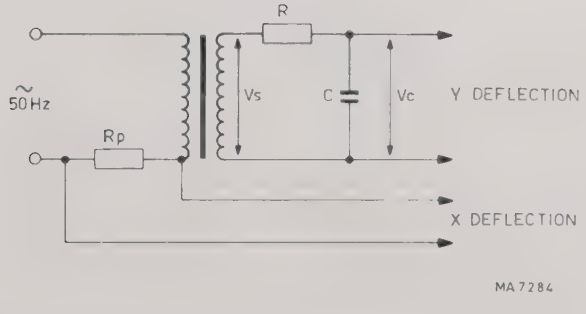


Fig. 2.8. Displaying a hysteresis loop, approximate method

The voltage across the secondary is $Vs = k \cdot \frac{dB}{dt}$, in which k is a constant. This voltage is integrated by an RC network ($R \gg \frac{1}{\omega C}$). The voltage across the capacitor then becomes $Vc = \frac{kB}{RC}$.

The induction B is, thus, proportional to the voltage across the capacitor. This voltage is fed to the Y_B input. This method is an approximation, as it is not possible to have a phase difference of 90° between input and output voltage.

An exact method is shown in Fig. 2.9., but, for this, the transformer must have a filament supply winding with a centre tap or two separate filament supply winding with the same supply voltages.

In the latter case, the two windings must be connected in series, the connection point serving as a centre tap. The 90° phase difference can be obtained by adjusting the 100 kΩ potentiometer.

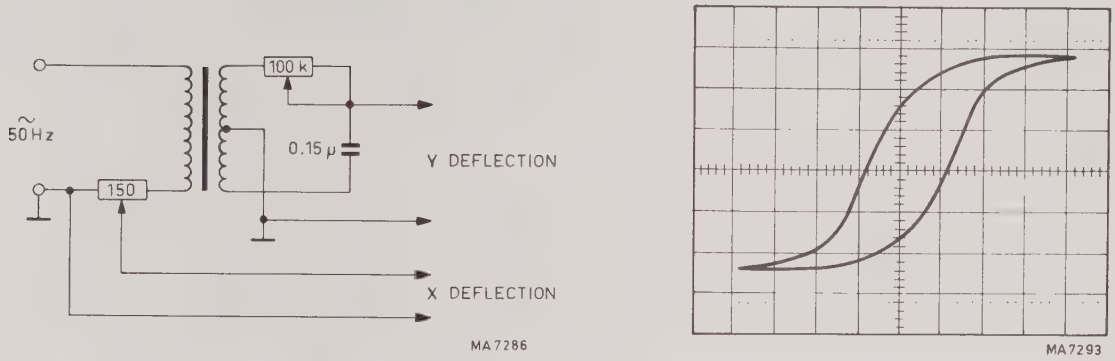


Fig. 2.9. Displaying a hysteresis loop, exact method

2.3.4.2. Displaying a diode characteristic

In displaying a diode characteristic, the current through the diode is plotted as a function of the voltage across the diode. For this, the circuit shown in Fig. 2.10. can be used. Voltage source V supplies a 50 Hz sine-wave voltage of approx. 20 V_{rms}.

The resistance R must be small compared to the expected internal resistance of the diode. The voltage across R, which is directly proportional to the anode current, is fed to the Y_B input. The anode voltage is applied to the Y_A input (TIME/cm switch to position X via Y_A). Then a curve is displayed which represents the relationship between anode current (vertical) and anode voltage (horizontal).

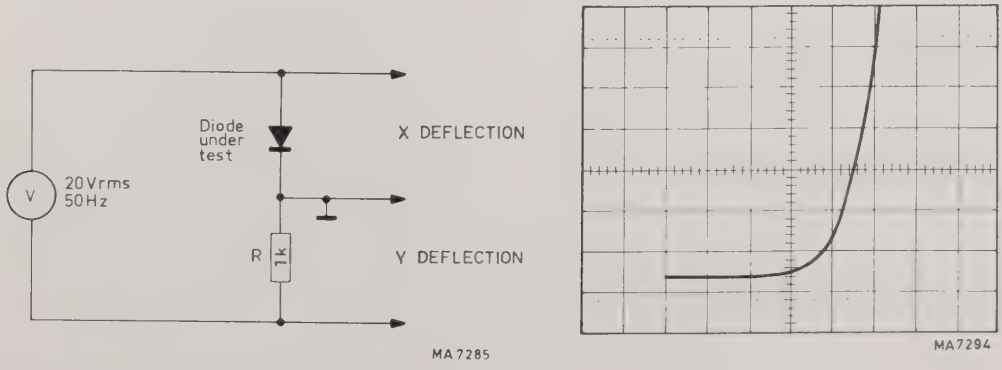


Fig. 2.10. Displaying the $I_A - V_A$ characteristic of a germanium diode

2.4. Some basic concepts

2.4.1. DEFINITIONS

2.4.1.1. Y deflection coefficient or sensitivity (V/cm or V/div.)

Indicates the peak-to-peak value of the input voltage required to bring about a deflection of the beam over a distance of 1 cm or 1 division in vertical direction.

2.4.1.2. Bandwidth or frequency range (Hz)
See Fig. 2.11.

This is the complete range of frequencies for which the deflection coefficient does not change more than 3 dB (approx. 30 %) with respect to the flat part of the frequency response curve. Beyond the 3 dB points, the response curve of good amplifiers as are used in the PM 3232 and PM 3233 oscilloscopes roll off with 6 dB per octour to ensure an optimum pulse response.

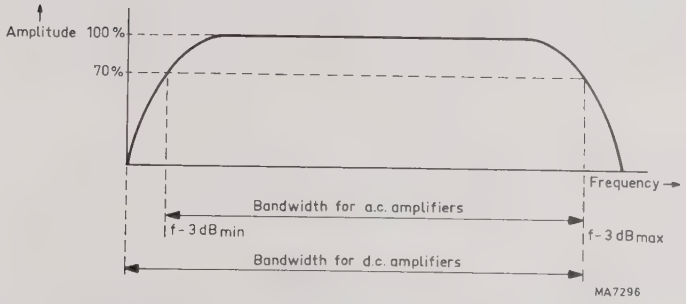


Fig. 2.11. Frequency response curve

2.4.1.3. Pulse rise time or fall time (ns)
See Fig. 2.12.

The time interval within which the voltage or current of the edge of a rectangular pulse passes from 10 % to 90 % (90 % to 10 %) of its full amplitude.
When amplifiers have a proper pulse response, the following relation between rise time (t_r) and −3 dB bandwidth (BW) is approximately true:
t_r (ns) . BW (MHz) = 350.

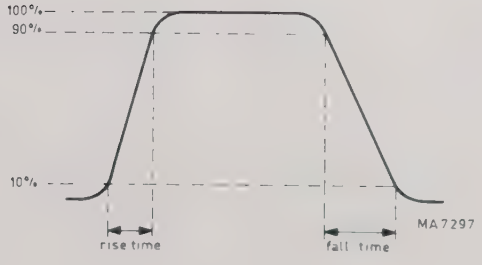


Fig. 2.12. Pulse rise and fall time

2.4.1.4. Overshoot (%)
See Fig. 2.13.

Overshoot is that part of the initial response which exceeds the steady-state value of the response to a rectangular pulse. It is expressed as a percentage of the steady-state value.

$$\text{Overshoot} = \frac{\Delta A}{A} \cdot 100\ \%$$

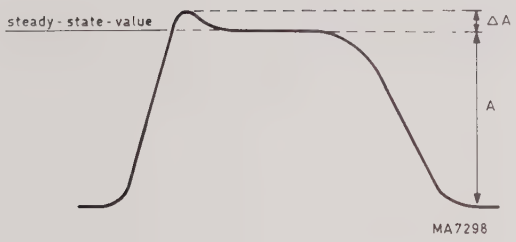


Fig. 2.13. Overshoot

2.4.1.5. Pulse tilt, also known as droop or sag (%)
See Fig. 2.14.

This is the difference between the initial and final amplitude of the representation of a rectangular pulse or square-wave, ignoring overshoot and other distortions.
It is expressed as a percentage of the initial amplitude and for a specified pulse duration.

$$\text{Pulse tilt} = \frac{\Delta A}{A} \cdot 100\ \%$$

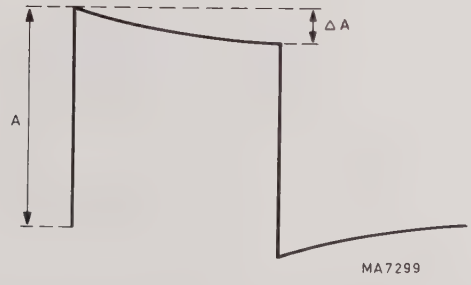


Fig. 2.14. Pulse tilt

2.4.1.6. Other pulse distortions
See Figs. 2.15. & 2.16. & 2.17.

Fig. 2.15. Ringing
Fig. 2.16. Preshoot
Fig. 2.17. Rounding

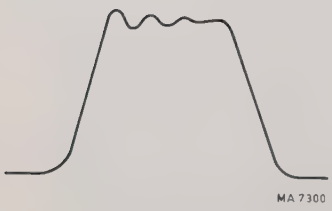


Fig. 2.15. Ringing

Fig. 2.16. Preshoot

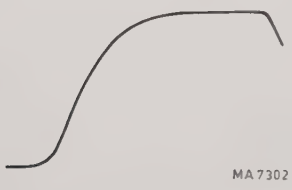


Fig. 2.17. Rounding

2.4.1.7. Pulse duration or width and repetition time
See Fig. 2.18.

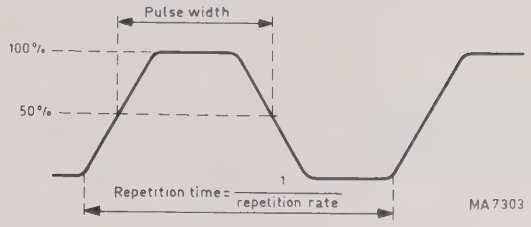


Fig. 2.18. Pulse width

2.4.1.8. Input impedance (MOhm//pF)

The input impedance is the final value calculated by combining the input resistance and capacitance in parallel.

2.4.1.9. Triggering

Triggering is the action of starting each individual sweep of the time base by means of a control voltage.
When there is no control voltage the time-base generator remains in a waiting position and no trace is visible on the screen.
Triggering can be either periodical or irregular.
In the triggered mode, any value of the time coefficient can be chosen independently of the period of the observed quantity, and without affecting the stability of the display. Triggering has also the advantage that the time-base can be calibrated.

2.4.1.10. Hold-off circuit

This is a circuit incorporated in the time-base generator, it prevents the sweep from being re-triggered until the spot has returned to its rest position and the circuit elements have completely relaxed.

2.4.2. DRIFT REDUCTION

The drift inherent in the sensitive d.c. coupled pre-amplifier is reduced by feedback via a control amplifier. We shall now calculate the effect of the control amplifier with reference to Fig. 2.19. in which A is the gain factor of the pre-amplifier and B that of the control amplifier. Resistors R are equal.

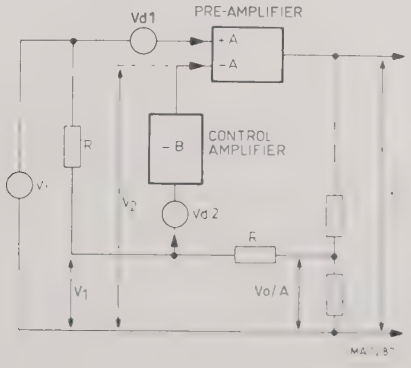


Fig. 2.19. Block diagram of the drift-reduction circuit

We regard the drift voltages from pre-amplifier and control amplifier as being due to d.c. voltage sources at the input (Vd1 and Vd2). We then find:

$$V1 = \frac{Vi + \frac{Vo}{A}}{2} \tag{1}$$

$$V2 = -B\,(V1 + Vd2) \tag{2}$$

$$Vo = A\,(V2 - Vi - Vd1) \tag{3}$$

It follows from (1) and (3) that:

$$V1 = \frac{Vi + \frac{A\,(V2 - Vi - Vd1)}{A}}{2} = \frac{V2 - Vd1}{2}$$

Substituting this result in (2) gives:

$$V2 = -B\,(\frac{V2 - Vd1}{2} + Vd2) \qquad \text{or}$$

$$V2\,(1 + \frac{B}{2}) = \frac{B}{2}\,Vd1 - BVd2 \qquad \text{or}$$

$$V2 = \frac{BVd1}{2 + B} - \frac{BVd2}{1 + \frac{B}{2}}$$

Substituting this result in (3) gives:

$$\frac{Vo}{A} = (\frac{B}{2 + B} - 1)\,Vd1 - \frac{BVd2}{1 + \frac{B}{2}} - Vi \qquad \text{or}$$

$$-\frac{Vo}{A} = Vi + \frac{2}{2 + B}\,Vd1 + \frac{B}{1 + \frac{B}{2}}\,Vd2 \qquad \text{or}$$

$$-\frac{Vo}{A} = Vi + \frac{1}{1 + \frac{B}{2}}\,Vd1 + \frac{2}{1 + \frac{2}{B}}\,Vd2$$

The last two terms represent drift voltages which are equivalent to a drift voltage:

$$Vd = \frac{1}{1 + \frac{B}{2}}\,Vd1 + \frac{2}{1 + \frac{2}{B}}\,Vd2$$

at the input.

We see that the drift of the pre-amplifier is reduced by a factor $(1 + \frac{B}{2})$. On the other hand, we have an extra drift due to the control amplifier, which is given by $\frac{2}{1 + \frac{2}{B}}\,Vd2 \approx 2Vd2$.

The drift of the control amplifier, however, is so low (because of strong thermal coupling of the amplifier transistors, and optimum design) that the term 2Vd2 can be neglected.

2.4.3. SERIES AND SHUNT FEEDBACK AMPLIFIER

Most of the amplifier stages used in the PM 3232 and PM 3233 are amplifiers with series and shunt feedback. A typical example of such an amplifier is shown in Fig. 2.20.

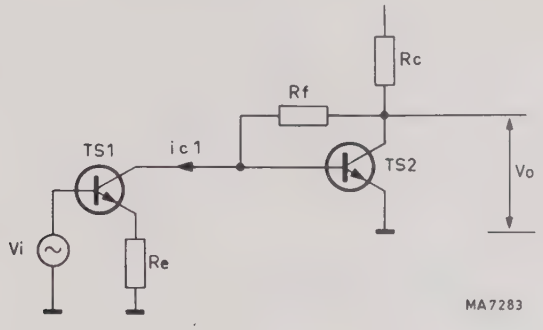


Fig. 2.20. Amplifier with series and shunt feedback

If we neglect the base current of TS2, it will be clear that the current through R_e also flows through R_f.

The transfer ratio $\frac{i_c}{v_i}$ in a series feedback amplifier stage is approximately $\frac{1}{R_e}$.

The transfer ratio $\frac{v_o}{i_c}$ in a shunt feedback amplifier stage is approximately R_f.

Thus, the voltage gain of the whole amplifier $A_v = \frac{e_o}{e_i}$ is near enough $\frac{R_f}{R_e}$ and depends only on the passive elements R_f and R_e.

2.4.4. THE DUAL-BEAM TUBE

The cathode-ray tube used in the PM 3232 and PM 3233 oscilloscopes is a dual-beam tube in which two beams are generated in one gun and can be deflected independently.
This arrangement is also known as split-beam tube.

In this tube, both time-base lines are exactly in parallel as they originate from one point and are under the influence of one common horizontal amplifier. Because the two traces originate from one gun, they show little distortion in relation to one another.

The split-beam tube is very suitable for displaying signals with a low repetition rate at relatively fast sweep speeds, since it may be regarded as a tube with a chopper with an infinitely high chopper frequency.

2.4.5. FROM THE COLD INTO THE WARMTH

In section 1.2. Characteristics you can read that the instrument works within the specifications after a warm-up period of five minutes and at an ambient temperature between +5 °C and +40 °C.
There is, however, one exception. If you leave, for instance, your oscilloscope in your car overnight when it is freezing and then bring it into a room with a temperature of 25 °C the following morning, condensation will occur on the components.

The high-ohmic resistors in your oscilloscope then cease to be high-ohmic because of leakage currents over the condensation, and the oscilloscope does not work properly. In this situation, you must allow approximately 2 hours for your oscilloscope to acclimatize until all condensation has evaporated.

2.5. Brief checking procedure

2.5.1. STARTING POSITIONS OF THE CONTROLS

- Push-buttons Y_A SK4, + SK8 and BEAM SELECTOR A SK14 & B SK15 depressed.
- TIME/cm switch SK2 to .1 ms.
- AMPL switches SK17 & SK18 to .1 V/cm.
- MAGN switch SK1 to x1
- POSITION potentiometers R1, R11 and R12 to their mid-positions.
- INTENS potentiometer R10 fully clockwise.
- TIME/cm and AMPL potentiometers R2, R4 and R5 to CAL.

Unless otherwise stated, the controls always occupy the same position as in the previous check.

2.5.2. C.R.T. POSITION

- Adjust FOCUS potentiometer R9 and INTENS potentiometer R10 for a well-defined display.
- Centre both time-base lines, using POSITION potentiometers R1, R11 and R12.
- Check that the time-base line runs exactly in parallel with the horizontal graticule lines.
  Correction possible with potentiometer R813 (Fig. 2.21.).

2.5.3. VERTICAL CHANNELS

The check for channel Y_A is described, that for Y_B is mentioned in brackets.

- Release BEAM SELECTOR B SK15 (A SK14).
- AC-0-DC switches SK16 & SK19 to 0.
- AMPL switch SK17 (SK18) to 2 mV/cm.
- Check that the time-base line remains within 4 mm in the centre of the screen. Correction possible with DC BAL potentiometer R6 (R7).
- AC-0-DC switch SK16 (SK19) to DC.
- Check that the time-base line has not moved more than 4 mm. Correction possible with potentiometer R126 (R326) (Fig. 2.23.).
- AMPL switch SK17 (SK18) to .1V/cm.
- Apply a square-wave voltage of 600 mV_{p-p} ± 0,5 %, 2 kHz, to Y_A (Y_B) input socket BU3 (BU5).
- Check that the trace height is 6 cm ± 2 %.
  Correction possible with R111 (R311), Fig. 2.23.
- Increase the frequency of the input voltage to 10 MHz.
- Check that the trace height is at least 4,2 cm.

2.5.4. X VIA Y_A

- Depress BEAM SELECTOR A SK14 and B SK15.
- Set TIME/cm switch SK2 to X via Y_A.
- AC-0-DC switch SK19 to 0.
- Apply a square-wave voltage of 600 mV_{p-p} ± 0,5 %, 2 kHz, to Y_A input socket BU3.
- Check that the trace width is 6 cm ± 3 %.
  Correction possible with potentiometer R601 (Fig. 2.22.).

2.5.5. TIME-BASE

- Check the time-coefficient in position 20 μs of TIME/cm switch SK2 by means of time markers.
  Tolerance ± 5 %. Correction possible with potentiometer R534 (Fig. 2.22.).
- Check the other time-coefficients; tolerance ± 5 %.

2.5.6. TRIGGERING

- Apply a sine-wave voltage of 100 mV_{p-p}, 10 MHz, to Y_A input BU3.
- Check that it is possible to adjust LEVEL potentiometer R3 for a stationary display.

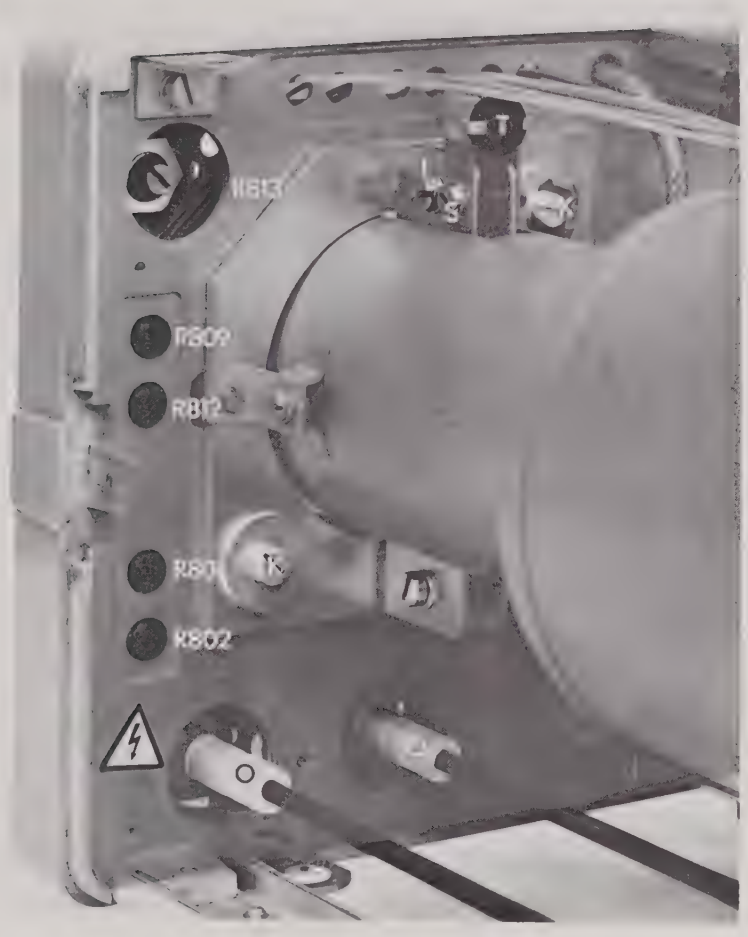


Fig. 2.21. Adjusting components

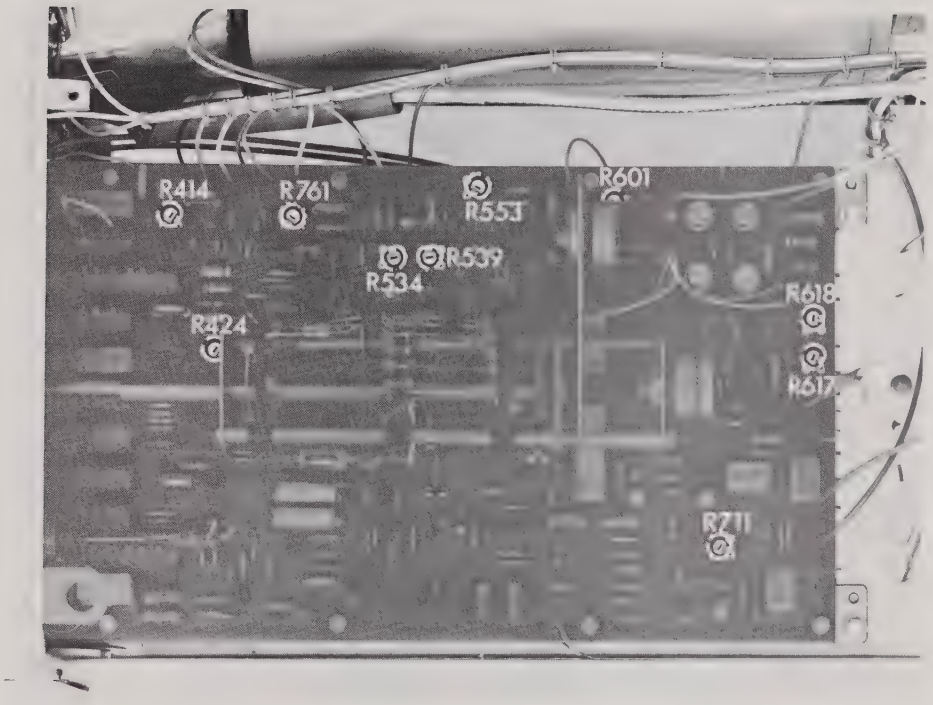


Fig. 2.22. Adjusting components

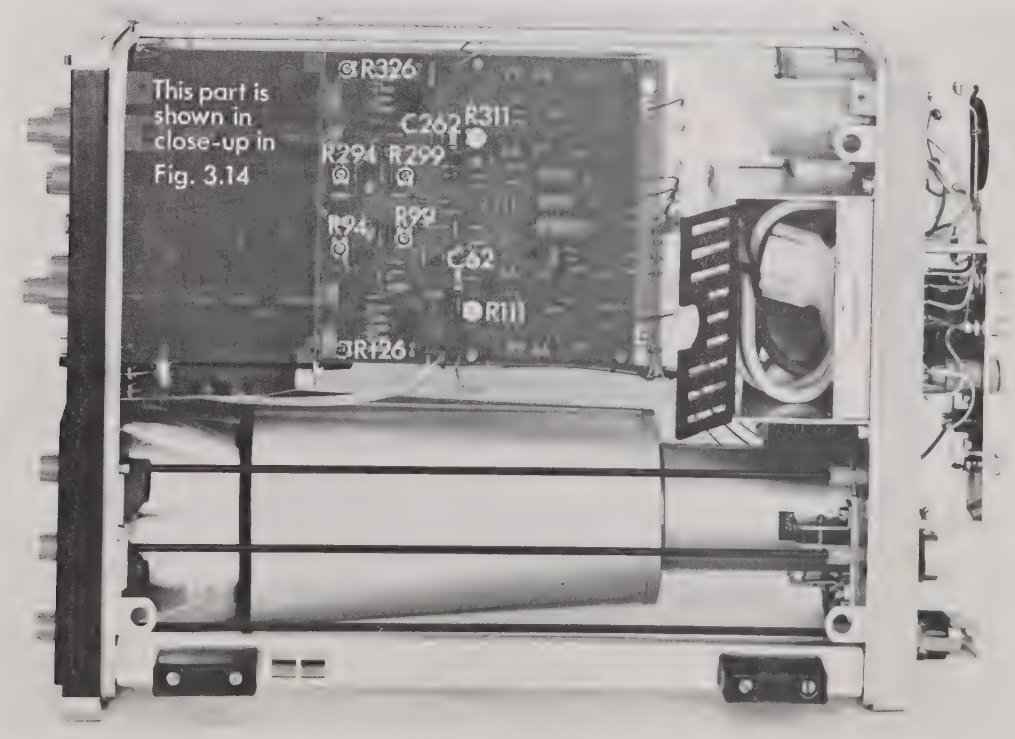


Fig. 2.23. Adjusting components (PM 3232)

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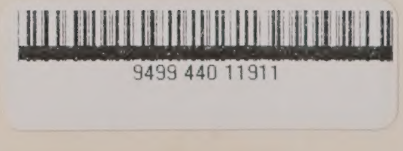
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